FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: **112740-331**

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR): **09/980857**

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/01348	**28 April 2000**	**28 April 1999**

TITLE OF INVENTION

HANDS-FREE DEVICE AND METHOD FOR OPERATING SAME

APPLICANT(S) FOR DO/EO/US

Karl Heinz Pflaum

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (24) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☒ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☒ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☒ Certificate of Mailing by Express Mail
23. ☐ Other items or information:

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/980857	PCT/DE00/01348	112740-331

24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS PTO USE ONLY
☐	Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	**$1040.00**
☒	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	**$890.00**
☐	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	**$740.00**
☐	International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	**$710.00**
☐	International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	**$100.00**
	ENTER APPROPRIATE BASIC FEE AMOUNT =	**$890.00**
	Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$0.00**

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	14 - 20 =	0	x $18.00	**$0.00**	
Independent claims	2 - 3 =	0	x $84.00	**$0.00**	
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**	
	TOTAL OF ABOVE CALCULATIONS =			**$890.00**	
☐	Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.			**$0.00**	
	SUBTOTAL =			**$890.00**	
	Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +			**$0.00**	
	TOTAL NATIONAL FEE =			**$890.00**	
☐	Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			**$0.00**	
	TOTAL FEES ENCLOSED =			**$890.00**	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of **$890.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **02-1818** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

William E. Vaughan
NAME

39,056
REGISTRATION NUMBER

October 24, 2001
DATE

BOX PCT

IN THE UNITED STATES ELECTED/DESIGNATED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

PRELIMINARY AMENDMENT

APPLICANT:	Karl Heinz Pflaum	DOCKET NO: 112740-331
SERIAL NO:		GROUP ART UNIT:
		EXAMINER:
INTERNATIONAL APPLICATION NO:		PCT/DE00/01348
INTERNATIONAL FILING DATE:		28 April 2000
INVENTION:	HANDS FREE DEVICE AND METHOD FOR OPERATING SAME	

Assistant Commissioner for Patents,
Washington, D.C. 20231

Sir:

Please amend the above-identified International Application before entry into the National stage before the U.S. Patent and Trademark Office under 35 U.S.C. §371 as follows:

In the Specification:

Please replace the Specification of the present application, including the Abstract, with the following Substitute Specification:

SPECIFICATION

TITLE OF THE INVENTION

HANDS FREE DEVICE AND METHOD FOR OPERATING SAME

BACKGROUND OF THE INVENTION

A hands-free device of this generic type, as described, for example, in DE 44 47 028 C1, allows a telephone call to be made without having to hold a telephone handset or the mobile station of a cordless telephone or of a mobile radio network in the hand and against the head. It allows the person using the telephone to have a high degree of freedom of movement in the room in which that person is located.

Dispensing with the fixed physical arrangement of the microphone, loudspeaker, mouth and ear of the person using the telephone requires a departure from the normal fixed amplification in the transmission channel and receiving channel in a normal telephone, since such a fixed gain in conjunction with highly variable distances between the mouth, microphone and ear/loudspeaker would frequently lead to unpleasant feedback effects adversely affecting the quality of communication in an unacceptable manner. A controllable attenuation device is therefore provided both in the transmission signal path and in the received signal path of a hands-free device, with these attenuation devices having an associated attenuation control device ("level balance") which ensures a predetermined level range. The level range is set so as to preclude feedback effects (feedback whistling) in all practical operating states.

In the case of telephones having an analog line connection (two-wire exchange line), the so-called line hybrid, that is to say the circuit which ensures the connection and signal conversion between the two-wire exchange line and the four-wire line within the terminal, is a critical element to the operation of the hands-free device. This is because, compliance with the stability criterion (overall gain in the electrical and acoustic part of the loop < 1) which governs operation of the hands-free control loop is governed essentially by the crosstalk in the line hybrid. This crosstalk is, in turn, governed by the nature of the line termination at the exchange end or in the local private branch exchange. The extreme cases here are, firstly, the short-circuited line and, secondly, the unterminated line (open-circuit operation). The attenuation level of the hands-free device is set for the latter operating situation, to be precise to the maximum attenuation level value, since the gain of the line hybrid reaches a maximum value in this case. However, since this situation cannot occur in practice once the connection has been set up, known hands-free devices operate with an unnecessarily high attenuation level in virtually all operating situations.

EP 0 376 582 discloses a hands-free device having a transmission signal path which has a programmable attenuation device, a received signal path which has a received signal attenuation device, a computer which is connected on the

output side to the programmable attenuation device and to the programmable attenuation device, as well as a line hybrid which connects the transmission signal path to the received signal path and connects the hands-free device to a telephone line. In this line hybrid the hands-free device is matched to the acoustic environment by determining the acoustic environment and carrying out a calibration process, controlled by the computer, via a test tone signal which passes through the circuit at two different signal levels.

The present invention is, thus, directed toward an improved hands-free device and an improved method for operating a hands-free device, in both of which the attenuation level can be set as required in practice.

SUMMARY OF THE INVENTION

The present invention includes the fundamental idea of using a specific test signal to measure the attenuation of the line hybrid in the telephone that corresponds to the line termination state at that time, and to define the attenuation and the attenuation level required in the received signal path and the transmission signal path according to the current situation and on the basis of the result obtained. It also includes the idea of using a specific test method which is based on the principle of correlation analysis, but which can be practiced permanently and in all operating situations without any effects on the communication quality. This is because the use of the correlation technique makes it possible to use a test signal at a level which is considerably, by orders of magnitude, lower than the useful signal, and which is inaudible by the telephone subscriber.

In one preferred embodiment, a predetermined test signal sequence, which is particularly suitable for use of correlation analysis, is produced cyclically and, after passing through the line hybrid, is sampled and accumulated, likewise cyclically, in a signal accumulator which is operated in synchronism with the test signal generator. Since the test signal sequence is correlated with itself, accumulation of this sequence has the effect of addition with a weighting factor of 1, while the useful signal is subject to addition of a weighting factor of only $1/\sqrt{2}$, owing to the lack of autocorrelation in it. Each accumulation of the total signal thus results in the signal-to-noise ratio being improved by 3 dB. Provided there are a

sufficient number of accumulation steps, this results in the test signal level being raised with respect to the useful signal even when, as already mentioned, the test signal level is considerably lower than the useful signal level.

After the accumulation processes, the predetermined, organized test signal sequence allows the attenuation of the line hybrid in the test time period to be determined precisely, and allows the attenuation control device to set an attenuation level that is reasonable for the operating state (at the connection end) at that time, on this basis.

Particularly suitable signal sequences for the test signal sequence are those which satisfy the criterion that their autocorrelation function disappears except at one point. These sequences are often referred to as a "maximum sequence" and can be produced, for example, by a shift register with feedback. The test signal sequence is, in the simplest case, a sequence of binary voltage signals (for example, + 1 V and - 1 V, or + 1 V and 0).

The test signal is attenuated by a test signal sequence attenuation element (attenuator), which is preferably controllable, to a suitable extent, and is added to the useful signal (transmission voice signal). The level of the total signal, including the test signal, is reduced via the line hybrid by a factor corresponding to the attenuation in the line hybrid, and is then sampled by a sampling device which has an A/D converter, in synchronism with the production of the test signal. The samples are supplied to the signal accumulator, for example to a cyclic buffer whose length is the same as that of the test signal sequence, and are added up there. After a predetermined number of accumulations, which number is matched to the signal level ratio of the test signal and useful signal, the signal accumulator or buffer is read, and the values that are read are supplied to an evaluation device. In practice, the number of accumulation steps to be provided must be greater than 50, and preferably greater than 150, in order to allow sensible processing of a test signal whose level is at least 30 dB, and preferably more than 60 dB, below that of the useful signal.

In the simplest case, the evaluation device evaluates the test signal purely on the basis of its energy by, in particular, forming the sum of the squares of the level

values corresponding to the individual buffer points. If this results in a high total energy, then the line hybrid has a high level of undesirable coupling at that time, and the attenuation level of the hands-free device must be increased. If, on the other hand, the evaluation results in a low total energy value, then the amount of undesirable coupling that is present is low, and the attenuation level can be reduced.

It is more appropriate to evaluate the accumulated signal or buffer contents using known spectral analysis methods, for example via a Fast Fourier Transformation, by which the transfer function of the line hybrid at that time can be obtained. Frequency-selective control of the attenuation level is then also possible on this basis.

In one embodiment, the attenuation control can be carried out on the basis, firstly, of the evaluation result at that time and, secondly, of a comparison criterion stored in advance (or a number of comparison values). Then, in addition to the signal input for evaluation of data representing the test signal, the attenuation control device has a reference value memory and a comparator unit, which is connected, firstly, to the data input and, secondly, to the reference value memory and, depending on the complexity, which is, of course, matched to the complexity of the evaluation device, outputs a control signal or a control signal sequence to the attenuation devices in the transmission signal path and in the received signal path. The specific configuration of the attenuation devices is also matched to the design of the evaluation device and, accordingly, allows either undifferentiated setting or frequency-selective setting of the attenuation in the respective signal path or channel.

Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows a schematic illustration of one embodiment of the present invention, in the form of a functional block diagram.

Figure 2 shows a schematic illustration to explain a computer-aided simulation of one specific implementation of the embodiment sketched in Figure 1.

Figures 3a to 3c show illustrations, in the form of graphs, of a test signal sequence which is used for the simulation shown in Figure 2, of the corresponding signal accumulation result, and the frequency response of the line hybrid that is used.

DETAILED DESCRIPTION OF THE INVENTION

As a preferred exemplary embodiment, Figure 1 shows a hands-free device 1 for a telephone with an analog line connection 3. The connection between the line connection 3 and a transmission signal path 5, as well as a received signal path 7, is provided by a line hybrid 9 which, in principle, is in the form of a Wheatstone Bridge, in which one of the bridge resistances is the line termination resistance at that time. The transmission signal path has a microphone 11, a speech amplifier 13 and a variable transmission signal attenuation device 15 and, in a similar manner, the received signal path 9 has a variable received signal attenuation device 17, an audio output amplifier 19 and a loudspeaker 21. An attenuation control device or level balance 23 is connected on the output side to the transmission signal attenuation device 15 and to the received signal attenuation device 17, in order to control them.

A test signal generator 27 with a downstream variable attenuation element 29 is included in the transmission signal path 5 loop via a coupler element 25, which is provided in the transmission signal path between the transmission signal attenuator device 15 and the line hybrid 9. An A/D converter 31 is included in the loop in the received signal path 7 between the line hybrid 9 and the received signal attenuation device 17, and is connected on the output side to a cyclic buffer 33. A measurement control unit 35 is connected on the output side both to the attenuation element 29 (in order to set its attenuation) and to control inputs of the test signal generator 27, of the A/D converter 31 and of the cyclic buffer 33 in order to synchronize the operation of these components.

An evaluation unit 37 is connected to the output of the cyclic buffer 33 and can carry out an energy-content evaluation or, alternatively, a spectral analysis of

the data set read from the cyclic buffer 33. On the output side, the evaluation unit 37 is connected to a first input of a comparator unit 23a, which is contained in the attenuation control device 23 and whose second input is connected to a reference value memory 39 in which energy content reference values and transfer function reference values are stored as a reference base for the respective output signal from the evaluation unit 37.

The test signal generator 27 produces a predetermined test signal sequence (for example, of the type shown in Figure 3a) which is suitable for correlation evaluation purposes and is subjected in the attenuation element 29 to predetermined attenuation matching the electrical and acoustic parameters of the specific hands-free device and its area of operation, and is then fed into the transmission signal path 5 via a coupler element 25. The test signal sequence, which includes a predetermined number of binary elements and has a predetermined duration, is output cyclically and repeatedly, controlled by the measurement control unit 35.

The line hybrid 9 is sampled cyclically via the A/D converter 31, controlled by the measurement control unit 35 and in synchronism with it, and the samples are stored in an organized form in the cyclic buffer 33, whose length corresponds to the length of the test signal sequence. In one exemplary embodiment, in which the test signal is fed in at a level that is 60 dB below that of the useful transmission signal, the process of outputting the test signal sequence, sampling and storage of the digitized samples is repeated 150 times in order to obtain an evaluation result. This has the effect of signal accumulation 150 times and results in the test signal level of the output of the cyclic buffer 33 being considerably greater than the mean (uncorrelated) useful signal level.

The test signal sequence which is read is subjected to a Fast-Hadamard Transformation in the evaluation unit 37, and then to Fast Fourier Transformation in order to determine the transfer function of the line hybrid 9. (In a modified evaluation unit 37, only the total energy content of the transmitted signal is determined, by summation of the squares of the buffer values.) Finally, the actual control signals for controlling the transmission signal attenuation device 15 and the received signal attenuation device 17, and hence for setting the attenuation level for

the hands-free device 1, are obtained as the result of a comparison with a corresponding reference transmission curve (or a reference energy content value) in the comparator unit 23a.

Based on the illustration in Figure 1, Figure 2 shows a simulation that uses Mathcad/Simulink of the operation of the hands-free device explained above. The reference symbols are taken from Figure 1 and, at the same time, characterize the operation of the individual components, without any need to describe them in relatively great detail once again. It is worth mentioning that the line hybrid is simulated as a switchable parallel circuit having a Butterworth filter ("butter" block) and delay element ("$^{Z-5}$" block).

Figures 3a to 3c show a maximum sequence of link 31 as an example of a suitable test signal sequence (Figure 3a) and the values obtained as the result of 150-times summation of the samples on the simulated line hybrid 9 shown in Figure 2 (Figure 3b) compared with one another and the transmission curve of the chosen line hybrid (Figure 3c). It should be mentioned that the accumulation of the total signal provides a test signal sequence for the line hybrid which can be used even if the test signal level is very low (in the example -60 dB in comparison to the assumed useful signal level). This shows that the attenuation characteristic of the line hybrid can be recorded at any given time using a test signal which is well below the useful signal level, and hence without any interference with communication.

The implementation of the present invention is not restricted to the described embodiment, but is also possible in a large number of modified forms. For example, other suitable test signal sequences can be used, in particular, and components other than the cyclic buffer mentioned may be used for signal accumulation. In particular, the level and attenuation values mentioned should be regarded only as examples.

Indeed, although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

ABSTRACT OF THE DISCLOSURE

A hands-free device for a telephone station having a transmission signal attenuation device, a received signal attenuation device and an attenuation control device, which has a test signal generator for producing a predetermined test signal sequence at a level which is considerably lower than a useful transmission signal, and has a signal accumulator for receiving the total signal level, as well as having an evaluation device for determining a transmission characteristic of a line hybrid for the telephone station via correlation analysis.

In the claims:

On page 10, cancel line 1, and substitute the following left-hand justified heading therefor:

CLAIMS

Please cancel claims 1-13, without prejudice, and substitute the following claims therefor:

14. A hands-free device for a telephone station, comprising:

a transmission signal path having a transmission signal attenuation device;

a received signal path having a received signal attenuation device;

an attenuation control device connected on an output side to both the transmission signal attenuation device and the received signal attenuation device;

a line hybrid connecting the transmission signal path to the received signal path and connecting the telephone station to an exchange line;

a test signal generator connected to the transmission signal path, the test signal generator producing a predetermined test signal sequence with a test signal sequence duration and a test signal level which is considerably lower than a useful transmission signal level, and for feeding the predetermined test signal sequence to the transmission signal path;

a signal accumulator connected to the received signal path, the signal accumulator for organized reception of the signal level over an accumulation time period which is a multiple of the test signal sequence duration; and

an evaluation device connected on an input side to an output of the signal accumulator and connected on an output side to the attenuation control device, the

evaluation device for determining a transmission characteristic of the line hybrid via correlation analysis.

15. A hands-free device for a telephone station as claimed in claim 14, further comprising:

a measurement control unit for controlling both the test signal generator and the signal accumulator, wherein the test signal generator produces the test signal sequence cyclically, and the signal accumulator has a sampling device, which is operated cyclically in synchronism with the operation of the test signal generator and has an A/D converter, and a buffer memory, which is connected on an input side to the sampling device, and is loaded cyclically.

16. A hands-free device for a telephone station as claimed in claim 15, wherein the test signal generator produces a maximum sequence as the test signal sequence.

17. A hands-free device for a telephone station as claimed in claim 14, further comprising:

a test signal sequence attenuation element with variable attenuation following the test signal generator.

18. A hands-free device for a telephone station as claimed in claim 14, wherein the evaluation device determines a transfer function of the line hybrid from the output of the signal accumulator, wherein the evaluation device carries out a Fast-Hadamard transformation, followed by a Fast-Fourier transformation.

19. A hands-free device for a telephone station as claimed in claim 14, wherein the evaluation device determines test signal power transmitted to the line hybrid as a transmission characteristic.

20. A hands-free device for a telephone station as claimed in claim 14, wherein the test signal level is at least 30 dB below the useful transmission signal level, and the signal accumulator carries out at least 50 signal accumulations.

21. A hands-free device for a telephone station as claimed in claim 14, wherein the test signal level is at least 60 dB below the useful transmission signal level, and the signal accumulator carries out at least 150 signal accumulations.

22. A hands-free device for a telephone station as claimed in claim 14, further comprising:

a reference value memory as part of the attenuation control device for storing at least one reference value which corresponds to the transmission characteristic; and

a comparator unit as part of the attenuation control device which is connected both the reference value memory and to the output of the evaluation unit, the comparator unit receiving the transmission characteristic from the evaluation device and, as a result of a comparison with the stored reference value, outputting a control signal to at least one of the transmission signal attenuation device and the received signal attenuation device.

23. A hands-free device for a telephone station as claimed in claim 14, wherein the transmission signal attenuation device and the received signal attenuation device are designed for frequency-dependent attenuation of the transmission signal and the received signal, respectively, and the attenuation control device is designed to output frequency-specific attenuation control signals.

24. A method for operating a hands-free device for a telephone station, the method comprising the steps of:

producing a predetermined test signal sequence with a test signal sequence duration and a test signal level which is considerably lower than a useful transmission signal level in a test signal generator;

feeding the predetermined test signal sequence into a transmission signal path in the hands-free device;

receiving the signal level in an organized manner over an accumulation time period, which is a multiple of the test signal sequence, in a signal accumulator which is connected to a received signal path; and

determining a transmission characteristic of a line hybrid, which connects the telephone station to an exchange line, via correlation analysis in an evaluation device which is connected on an input side to the output of the signal accumulator and is connected on an output side to an attenuation control device for the hands-free device.

25. A method for operating a hands-free device for a telephone station as claimed in claim 24, wherein the test signal sequence is produced cyclically in the test signal generator, and cyclic sampling is carried out, in synchronism with the operation of the test signal generator, in the signal accumulator.

26. A method for operating a hands-free device for a telephone station as claimed in claim 24, the method further comprising the step of:

carrying out a Fast-Hadamard transformation followed by a Fast-Fourier transformation in the evaluation device.

27. A method for operating a hands-free device for a telephone station as claimed in claim 24, the method further comprising the step of:

evaluating the test signal power as a transmission characteristic.

REMARKS

The present amendment makes editorial changes and corrects typographical errors in the specification, which includes the Abstract, in order to conform the specification to the requirements of United States Patent Practice. No new matter is added thereby. Attached hereto is a marked-up version of the changes made to the specification by the present amendment. The attached page is captioned "**Version With Markings To Show Changes Made**".

In addition, the present amendment cancels original claims 1-13 in favor of new claims 14-27. Claims 14-27 have been presented solely because the revisions by crossing out underlining which would have been necessary in claims 1-13 in order to present those claims in accordance with preferred United States Patent Practice would have been too extensive, and thus would have been too burdensome. The present amendment is intended for clarification purposes only and not for substantial reasons related to patentability pursuant to 35 U.S.C. §§103, 102, 103 or 112. Indeed, the cancellation of claims 1-13 does not constitute an intent on the part of the Applicants to surrender any of the subject matter of claims 1-13.

Early consideration on the merits is respectfully requested.

Respectfully submitted,

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VERSIONS WITH MARKINGS TO SHOW CHANGES MADE

In The Specification:

The Specification of the present application, including the Abstract, has been amended as follows:

SPECIFICATION

TITLE OF THE INVENTION

~~Description~~

~~Hands-free device and a method for operating such a device~~

HANDS-FREE DEVICE AND METHOD FOR OPERATING SAME

BACKGROUND OF THE INVENTION

~~The invention relates to a hands-free device as claimed in the precharacterizing clause of claim 1, and to a method for operating a hands-free device.~~

A hands-free device of this generic type, as described, for example, in DE 44 47 028 C1, allows a telephone call to be made without having to hold a telephone handset or the mobile station of a cordless telephone or of a mobile radio network in the hand and against the head. It allows the person using the telephone to have a high degree of freedom of movement in the room in which that person is located.

Dispensing with the fixed physical arrangement of the microphone, loudspeaker, mouth and ear of the person using the telephone requires a departure from the normal fixed amplification in the transmission channel and receiving channel in a normal telephone, since such a fixed gain in conjunction with highly variable distances between the mouth, microphone and ear/loudspeaker would frequently lead to unpleasant feedback effects adversely affecting the quality of communication in an unacceptable manner. A controllable attenuation device is therefore provided both in the transmission signal path and in the received signal path of a hands-free device, with these attenuation devices having an associated attenuation control device ("level balance") which ensures a predetermined level range. The level range is set so as to preclude feedback effects (feedback whistling) in all practical operating states.

In the case of telephones having an analog line connection (two-wire exchange line), the so-called line hybrid, that is to say the circuit which ensures the connection and signal conversion between the two-wire exchange line and the four-wire line within the terminal, is a critical element to the operation of the hands-free device. This is because, compliance with the stability criterion (overall gain in the electrical and acoustic part of the loop < 1) which governs operation of the hands-free control loop is governed essentially by the crosstalk in the line hybrid. This crosstalk is, in turn, governed by the nature of the line termination at the exchange end or in the local private branch exchange. The extreme cases here are, firstly, the short-circuited line and, secondly, the unterminated line (open-circuit operation). The attenuation level of the hands-free device is set for the latter operating situation, to be precise to the maximum attenuation level value, since the gain of the line hybrid reaches a maximum value in this case. However, since this situation cannot occur in practice once the connection has been set up, known hands-free devices operate with an unnecessarily high attenuation level in virtually all operating situations.

EP 0 376 582 discloses a hands-free device having a transmission signal path which has a programmable attenuation device, a received signal path which has a received signal attenuation device, a computer which is connected on the output side to the programmable attenuation device and to the programmable attenuation device, as well as a line hybrid which connects the transmission signal path to the received signal path and connects the hands-free device to a telephone line~~,~~. ~~and in which~~ In this line hybrid the hands-free device is matched to the acoustic environment by determining the acoustic environment and carrying out a calibration process, controlled by the computer, ~~by means of~~ via a test tone signal which passes through the circuit at two different signal levels.

The present invention is, thus, ~~based on the object of specifying~~ directed toward an improved hands-free device and an improved method for operating a hands-free device, in both of which the attenuation level can be set as required in practice.

~~With regard to its apparatus aspect, this object is achieved by a hands-free device having the features of claim 1, and with regard to its method aspect, it is achieved by a method having the features of claim 10.~~

SUMMARY OF THE INVENTION

The present invention includes the fundamental idea of using a specific test signal to measure the attenuation of the line hybrid in the telephone that corresponds to the line termination state at that time, and to define the attenuation and the attenuation level required in the received signal path and the transmission signal path according to the current situation and on the basis of the result obtained. It also includes the idea of using a specific test method which is based on the principle of correlation analysis, but which can be practiced permanently and in all operating situations without any effects on the communication quality. This is because the use of the correlation technique makes it possible to use a test signal at a level which is considerably, ~~that is to say~~ by orders of magnitude, lower than the useful signal, and which is inaudible by the telephone subscriber.

In one preferred embodiment, a predetermined test signal sequence, which is particularly suitable for use of correlation analysis, is produced cyclically and, after passing through the line hybrid, is sampled and accumulated, likewise cyclically, in a signal accumulator which is operated in synchronism with the test signal generator. Since the test signal sequence is correlated with itself, accumulation of this sequence has the effect of addition with a weighting factor of 1, while the useful signal is subject to addition of a weighting factor of only $1/\sqrt{2}$, owing to the lack of autocorrelation in it. Each accumulation of the total signal thus results in the signal-to-noise ratio being improved by 3 dB. Provided there are a sufficient number of accumulation steps, this ~~therefore~~ results in the test signal level being raised with respect to the useful signal even when, as already mentioned, the test signal level is considerably lower than the useful signal level.

After the accumulation processes, the predetermined, organized test signal sequence allows the attenuation of the line hybrid in the test time period to be determined precisely, and allows the attenuation control device to set an attenuation

level that is reasonable for the operating state (at the connection end) at that time, on this basis.

Particularly suitable signal sequences for the test signal sequence are those which satisfy the criterion that their autocorrelation function disappears except at one point. These sequences are often referred to as a "maximum sequence" and can be produced, for example, by a shift register with feedback. The test signal sequence is, in the simplest case, a sequence of binary voltage signals (for example + 1 V and - 1 V, or + 1 V and 0).

The test signal is attenuated by a test signal sequence attenuation element (attenuator), which is preferably controllable, to a suitable extent, and is added to the useful signal (transmission voice signal). The level of the total signal, ~~that is to say, therefore,~~ including the test signal, is reduced via the line hybrid by a factor corresponding to the attenuation in the line hybrid, and is then sampled by a sampling device~~,~~ which has an A/D converter, in synchronism with the production of the test signal. The samples are supplied to the signal accumulator, for example to a cyclic buffer whose length is the same as that of the test signal sequence, and are added up there. After a predetermined number of accumulations, which number is matched to the signal level ratio of the test signal and useful signal, the signal accumulator or buffer is read, and the values that are read are supplied to an evaluation device. In practice, the number of accumulation steps to be provided must be greater than 50, and preferably greater than 150, in order to allow sensible processing of a test signal whose level is at least 30 dB, and preferably more than 60 dB, below that of the useful signal.

In the simplest case, the evaluation device evaluates the test signal purely on the basis of its energy by, in particular, forming the sum of the squares of the level values corresponding to the individual buffer points. If this results in a high total energy, then the line hybrid has a high level of undesirable coupling at that time, and the attenuation level of the hands-free device must be increased. If, on the other hand, the evaluation results in a low total energy value, then the amount of undesirable coupling that is present is low, and the attenuation level can be reduced.

It is more appropriate to evaluate the accumulated signal or buffer contents using known spectral analysis methods, for example ~~by means of~~ via a Fast Fourier Transformation, by ~~means of~~ which the transfer function of the line hybrid at that time can be obtained. Frequency-selective control of the attenuation level is then also possible on this basis.

In one ~~expedient~~ embodiment, the attenuation control can be carried out on the basis, firstly, of the evaluation result at that time and, secondly, of a comparison criterion stored in advance (or a number of comparison values). Then, in addition to the signal input for evaluation of data representing the test signal, the attenuation control device has a reference value memory and a comparator unit, which is connected, firstly, to the data input and, secondly, to the reference value memory and, depending on the complexity, which is, of course, matched to the complexity of the evaluation device, outputs a control signal or a control signal sequence to the attenuation devices in the transmission signal path and in the received signal path. The specific configuration of the attenuation devices is also matched to the design of the evaluation device and, accordingly, allows either undifferentiated setting or frequency-selective setting of the attenuation in the respective signal path or channel.

Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

~~Advantages and expedient features of the invention will, in addition to the above, become clear from the dependent claims and from the following description of an exemplary embodiment, with reference to the figures, in which:~~

BRIEF DESCRIPTION OF THE FIGURES

~~figure~~ Figure 1shows a schematic illustration of one embodiment of the present invention, in the form of a functional block diagram~~;~~.

Figure 2 shows a schematic illustration to explain a computer-aided simulation of one specific implementation of the embodiment sketched in ~~figure~~ Figure 1~~, and~~.

Figures 3a to 3c show illustrations, in the form of graphs, of a test signal sequence which is used for the simulation shown in ~~figure~~ Figure 2, of the corresponding signal accumulation result, and the frequency response of the line hybrid that is used.

DETAILED DESCRIPTION OF THE INVENTION

As a preferred exemplary embodiment, Figure 1 shows a hands-free device 1 for a telephone with an analog line connection 3. The connection between the line connection 3 and a transmission signal path 5_s as well as a received signal path 7_s is provided by a line hybrid 9 which, in principle, is in the form of a Wheatstone Bridge, in which one of the bridge resistances is the line termination resistance at that time. The transmission signal path has a microphone 11, a speech amplifier 13 and a variable transmission signal attenuation device 15, and, in a similar manner, the received signal path 9 has a variable received signal attenuation device 17, an audio output amplifier 19 and a loudspeaker 21. An attenuation control device or level balance 23 is connected on the output side to the transmission signal attenuation device 15 and to the received signal attenuation device 17, in order to control them.

A test signal generator 27 with a downstream variable attenuation element 29 is included in the transmission signal path 5 loop via a coupler element 25, which is provided in the transmission signal path between the transmission signal attenuator device 15 and the line hybrid 9. An A/D converter 31 is included in the loop in the received signal path 7 between the line hybrid 9 and the received signal attenuation device 17, and is connected on the output side to a cyclic buffer 33. A measurement control unit 35 is connected on the output side both to the attenuation element 29 (in order to set its attenuation) and to control inputs of the test signal generator 27, of the A/D converter 31 and of the cyclic buffer 33 in order to synchronize the operation of these components.

An evaluation unit 37 is connected to the output of the cyclic buffer 33 and ~~has means for carrying~~ can carry out an energy-content evaluation or, alternatively, a spectral analysis of the data set read from the cyclic buffer 33. On the output side, the evaluation unit 37 is connected to a first input of a comparator unit 23a, which

is contained in the attenuation control device 23 and whose second input is connected to a reference value memory 39 in which energy content reference values and transfer function reference values are stored as a reference base for the respective output signal from the evaluation unit 37.

The test signal generator 27 produces a predetermined test signal sequence (for example, of the type shown in ~~figure~~ Figure 3a) which is suitable for correlation evaluation purposes and is subjected in the attenuation element 29 to predetermined attenuation matching the electrical and acoustic parameters of the specific hands-free device and its area of operation, and is then fed into the transmission signal path 5 via a coupler element 25. ~~Said~~ The test signal sequence, which ~~comprises~~ includes a predetermined number of binary elements and has a predetermined duration, is output cyclically and repeatedly, controlled by the measurement control unit 35.

The line hybrid 9 is sampled cyclically via the A/D converter 31, controlled by the measurement control unit 35 and in synchronism with it, and the samples are stored in an organized form in the cyclic buffer 33, whose length corresponds to the length of the test signal sequence. In one exemplary embodiment, in which the test signal is fed in at a level that is 60 dB below that of the useful transmission signal, the process of outputting the test signal sequence, sampling and storage of the digitized samples is repeated 150 times in order to obtain an evaluation result. This has the effect of signal accumulation 150 times and results in the test signal level of the output of the cyclic buffer 33 being considerably greater than the mean (uncorrelated) useful signal level.

The test signal sequence which is read is subjected to a Fast-Hadamard Transformation in the evaluation unit 37, and then to Fast Fourier Transformation in order to determine the transfer function of the line hybrid 9. (In a modified evaluation unit 37, only the total energy content of the transmitted signal is determined, by summation of the squares of the buffer values.) Finally, the actual control signals for controlling the transmission signal attenuation device 15 and the received signal attenuation device 17, and hence for setting the attenuation level for the hands-free device 1, are obtained as the result of a comparison with a

corresponding reference transmission curve (or a reference energy content value) in the comparator unit 23a.

Based on the illustration in Figure 1, Figure 2 shows a simulation that uses Mathcad/Simulink of the operation of the hands-free device explained above. The reference symbols are taken from Figure 1 ~~thus~~ and, at the same time, ~~characterizing~~ characterize the operation of the individual components, without any need to describe them in relatively great detail once again. It is worth mentioning that the line hybrid is simulated as a switchable parallel circuit ~~comprising~~ having a Butterworth filter ("butter" block) and delay element ("$^{Z-5}$" block).

Figures 3a to 3c show a maximum sequence of link 31 as an example of a suitable test signal sequence (~~figure~~ Figure 3a) and the values obtained as the result of 150-times summation of the samples on the simulated line hybrid 9 shown in Figure 2 (Figure 3b) compared with one another and the transmission curve of the chosen line hybrid (Figure 3c). It should be mentioned that the accumulation of the total signal provides a test signal sequence for the line hybrid which can be used even if the test signal level is very low (in the example -60 dB in comparison to the assumed useful signal level). This shows that the attenuation characteristic of the line hybrid can be recorded at any given time using a test signal which is well below the useful signal level, and hence without any interference with communication.

The implementation of the present invention is not restricted to the described embodiment, but is also possible in a large number of modified forms. For example, other suitable test signal sequences can be used, in particular, and components other than the cyclic buffer mentioned may be used for signal accumulation. In particular, the level and attenuation values mentioned should be regarded only as examples.

Indeed, although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

~~Abstract~~

ABSTRACT OF THE DISCLOSURE

~~Hands-free device and a method for operating such a device~~

A hands-free device ~~(1)~~ for a telephone station having a transmission signal attenuation device ~~(15)~~, a received signal attenuation device ~~(17)~~ and an attenuation control device ~~(23)~~, which has a test signal generator ~~(27)~~ for producing a predetermined test signal sequence at a level which is considerably lower than a useful transmission signal, and has a signal accumulator ~~(31, 33)~~ for receiving the total signal level, as well as having an evaluation device for determining a transmission characteristic of a line hybrid ~~(9)~~ for the telephone station ~~by means of~~ via correlation analysis.

~~Figure 1~~

Hands-free device and a method for operating such a device

The invention relates to a hands-free device as claimed in the precharacterizing clause of claim 1, and to a method for operating a hands-free device.

A hands-free device of this generic type - as described, for example, in DE 44 47 028 C1 - allows a telephone call to be made without having to hold a telephone handset or the mobile station of a cordless telephone or of a mobile radio network in the hand and against the head. It allows the person using the telephone to have a high degree of freedom of movement in the room in which that person is located.

Dispensing with the fixed physical arrangement of the microphone, loudspeaker, mouth and ear of the person using the telephone requires a departure from the normal fixed amplification in the transmission channel and receiving channel in a normal telephone, since such a fixed gain in conjunction with highly variable distances between the mouth, microphone and ear/loudspeaker would frequently lead to unpleasant feedback effects adversely affecting the quality of communication in an unacceptable manner. A controllable attenuation device is therefore provided both in the transmission signal path and in the received signal path of a hands-free device, with these attenuation devices having an associated attenuation control device ("level balance") which ensures a predetermined level range. The level range is set so as to preclude feedback effects (feedback whistling) in all practical operating states.

In the case of telephones having an analog line connection (two-wire exchange line), the so-called line

hybrid, that is to say the circuit which ensures the connection and signal conversion between the two-wire exchange line and the four-wire line within the terminal,

is a critical element to the operation of the hands-free device. This is because, compliance with the stability criterion (overall gain in the electrical and acoustic part of the loop < 1) which governs operation of the hands-free control loop is governed essentially by the crosstalk in the line hybrid. This crosstalk is in turn governed by the nature of the line termination at the exchange end or in the local private branch exchange. The extreme cases here are, firstly, the short-circuited line and, secondly, the unterminated line (open-circuit operation). The attenuation level of the hands-free device is set for the latter operating situation, to be precise to the maximum attenuation level value - since the gain of the line hybrid reaches a maximum value in this case. However, since this situation cannot occur in practice once the connection has been set up, known hands-free devices operate with an unnecessarily high attenuation level in virtually all operating situations.

EP 0 376 582 discloses a hands-free device having a transmission signal path which has a programmable attenuation device, a received signal path which has a received signal attenuation device, a computer which is connected on the output side to the programmable attenuation device and to the programmable attenuation device, as well as a line hybrid which connects the transmission signal path to the received signal path and connects the hands-free device to a telephone line, and in which line hybrid the hands-free device is matched to the acoustic environment by determining the acoustic environment and carrying out a calibration process, controlled by the computer, by means of a test tone signal which passes through the circuit at two different signal levels.

The invention is thus based on the object of specifying an improved hands-free device and an improved method for operating a hands-free device, in both of which the attenuation level can be set as required in practice.

With regard to its apparatus aspect, this object is achieved by a hands-free device having the features of claim 1, and with regard to its method aspect, it is achieved by a method having the features of claim 10.

The invention includes the fundamental idea of using a specific test signal to measure the attenuation of the line hybrid in the telephone that corresponds to the line termination state at that time, and to define the attenuation and the attenuation level required in the received signal path and the transmission signal path according to the current situation and on the basis of the result obtained. It also includes

the idea of using a specific test method which is based on the principle of correlation analysis, but which can be practiced permanently and in all operating situations without any effects on the communication quality. This is because the use of the correlation technique makes it possible to use a test signal at a level which is considerably, that is to say by orders of magnitude, lower than the useful signal, and which is inaudible by the telephone subscriber.

In one preferred embodiment, a predetermined test signal sequence, which is particularly suitable for use of correlation analysis, is produced cyclically and, after passing through the line hybrid, is sampled and accumulated, likewise cyclically, in a signal accumulator which is operated in synchronism with the test signal generator. Since the test signal sequence is correlated with itself, accumulation of this sequence has the effect of addition with a weighting factor of 1, while the useful signal is subject to addition of a weighting factor of only $1/\sqrt{2}$, owing to the lack of autocorrelation in it. Each accumulation of the total signal thus results in the signal-to-noise ratio being improved by 3 dB. Provided there are a sufficient number of accumulation steps, this therefore results in the test signal level being raised with respect to the useful signal even when - as already mentioned - the test signal level is considerably lower than the useful signal level.

After the accumulation processes, the predetermined, organized test signal sequence allows the attenuation of the line hybrid in the test time period to be determined precisely, and allows the attenuation control device to set an attenuation level that is reasonable for the operating state (at the connection end) at that time, on this basis.

Particularly suitable signal sequences for the test signal sequence are those which satisfy the criterion that their autocorrelation function disappears except at one point. These sequences are often referred to as a "maximum sequence" and can

be produced, for example, by a shift register with feedback. The test signal sequence is, in the simplest case, a sequence of binary voltage signals (for example + 1 V and - 1 V, or + 1 V and 0).

The test signal is attenuated by a test signal sequence attenuation element (attenuator), which is preferably controllable, to a suitable extent, and is added to the useful signal (transmission voice signal). The level of the total signal, that is to say, therefore, including the test signal, is reduced via the line hybrid by a factor corresponding to the attenuation in the line hybrid, and is then sampled by a sampling device, which has an A/D converter, in synchronism with the production of the test signal. The samples are supplied to the signal accumulator, for example to a cyclic buffer whose length is the same as that of the test signal sequence, and are added up there. After a predetermined number of accumulations, which number is matched to the signal level ratio of the test signal and useful signal, the signal accumulator or buffer is read, and the values that are read are supplied to an evaluation device. In practice, the number of accumulation steps to be provided must be greater than 50, and preferably greater than 150, in order to allow sensible processing of a test signal whose level is at least 30 dB, and preferably more than 60 dB, below that of the useful signal.

In the simplest case, the evaluation device evaluates the test signal purely on the basis of its energy by, in particular, forming the sum of the squares of the level values corresponding to the individual buffer points. If this results in a high total energy, then the line hybrid has a high level of undesirable coupling at that time, and the attenuation level of the hands-free device must be increased. If, on the other hand, the evaluation results in a low total energy

value, then the amount of undesirable coupling that is present is low, and the attenuation level can be reduced.

It is more appropriate to evaluate the accumulated signal or buffer contents using known spectral analysis methods, for example by means of a Fast Fourier Transformation, by means of which the transfer function of the line hybrid at that time can be obtained. Frequency-selective control of the attenuation level is then also possible on this basis.

In one expedient embodiment, the attenuation control can be carried out on the basis, firstly of the evaluation result at that time and, secondly, of a comparison criterion stored in advance (or a number of comparison values). Then, in addition to the signal input for evaluation of data representing the test signal, the attenuation control device has a reference value memory and a comparator unit, which is connected firstly to the data input and secondly to the reference value memory and - depending on the complexity, which is, of course, matched to the complexity of the evaluation device - outputs a control signal or a control signal sequence to the attenuation devices in the transmission signal path and in the received signal path. The specific configuration of the attenuation devices is also matched to the design of the evaluation device and, accordingly, allows either undifferentiated setting or frequency-selective setting of the attenuation in the respective signal path or channel.

Advantages and expedient features of the invention will, in addition to the above, become clear from the dependent claims and from the following description of an exemplary embodiment, with reference to the figures, in which:

figure 1 shows a schematic illustration of one embodiment of the invention, in the form of a functional block diagram,

Figure 2 shows a schematic illustration to explain a computer-aided simulation of one specific implementation of the embodiment sketched in figure 1, and

Figures 3a to 3c show illustrations, in the form of graphs, of a test signal sequence which is used for the simulation shown in figure 2, of the corresponding signal accumulation result, and the frequency response of the line hybrid that is used.

As a preferred exemplary embodiment, Figure 1 shows a hands-free device 1 for a telephone with an analog line connection 3. The connection between the line connection 3 and a transmission signal path 5 as well as a received signal path 7 is provided by a line hybrid 9 which, in principle, is in the form of a Wheatstone Bridge, in which one of the bridge resistances is the line termination resistance at that time. The transmission signal path has a microphone 11, a speech amplifier 13 and a variable transmission signal attenuation device 15, and, in a similar manner, the received signal path 9 has a variable received signal attenuation device 17, an audio output amplifier 19 and a loudspeaker 21. An attenuation control device or level balance 23 is connected on the output side to the transmission signal attenuation device 15 and to the received signal attenuation device 17, in order to control them.

A test signal generator 27 with a downstream variable attenuation element 29 is included in the transmission signal path 5 loop via a coupler element 25, which is provided in the transmission signal path between the transmission signal attenuator device 15 and the line hybrid 9. An A/D converter 31 is included in the loop in the received signal path 7 between the line hybrid 9 and the received signal attenuation device 17, and is

connected on the output side to a cyclic buffer 33. A measurement control unit 35 is connected on the output side both to the attenuation element 29 (in order to set its attenuation) and to control inputs of the test signal generator 27, of the A/D

converter 31 and of the cyclic buffer 33 in order to synchronize the operation of these components.

An evaluation unit 37 is connected to the output of the cyclic buffer 33 and has means for carrying out an energy-content evaluation or, alternatively, a spectral analysis of the data set read from the cyclic buffer 33. On the output side, the evaluation unit 37 is connected to a first input of a comparator unit 23a, which is contained in the attenuation control device 23 and whose second input is connected to a reference value memory 39 in which energy content reference values and transfer function reference values are stored as a reference base for the respective output signal from the evaluation unit 37.

The test signal generator 27 produces a predetermined test signal sequence (for example of the type shown in figure 3a) which is suitable for correlation evaluation purposes and is subjected in the attenuation element 29 to predetermined attenuation matching the electrical and acoustic parameters of the specific hands-free device and its area of operation, and is then fed into the transmission signal path 5 via a coupler element 25. Said test signal sequence, which comprises a predetermined number of binary elements and has a predetermined duration, is output cyclically and repeatedly, controlled by the measurement control unit 35.

The line hybrid 9 is sampled cyclically via the A/D converter 31, controlled by the measurement control unit 35 and in synchronism with it, and the samples are stored in an organized form in the cyclic buffer 33, whose length corresponds to the length of the test signal sequence. In one exemplary embodiment, in which the test signal is fed in at a level that is 60 dB below that of the useful transmission signal, the process of outputting the test signal sequence,

sampling and storage of the digitized samples is repeated 150 times in order to obtain an evaluation result. This has

the effect of signal accumulation 150 times and results in the test signal level of the output of the cyclic buffer 33 being considerably greater than the mean (uncorrelated) useful signal level.

The test signal sequence which is read is subjected to a Fast-Hadamard Transformation in the evaluation unit 37, and then to Fast Fourier Transformation in order to determine the transfer function of the line hybrid 9. (In a modified evaluation unit 37, only the total energy content of the transmitted signal is determined, by summation of the squares of the buffer values.) Finally, the actual control signals for controlling the transmission signal attenuation device 15 and the received signal attenuation device 17, and hence for setting the attenuation level for the hands-free device 1, are obtained as the result of a comparison with a corresponding reference transmission curve (or a reference energy content value) in the comparator unit 23a.

Based on the illustration in Figure 1, Figure 2 shows a simulation that uses Mathcad/Simulink of the operation of the hands-free device explained above. The reference symbols are taken from Figure 1 thus, at the same time characterizing the operation of the individual components - without any need to describe them in relatively great detail once again. It is worth mentioning that the line hybrid is simulated as a switchable parallel circuit comprising a Butterworth filter ("butter" block) and delay element ("z^{-5}" block).

Figures 3a to 3c show a maximum sequence of link 31 as an example of a suitable test signal sequence (figure 3a) and the values obtained as the result of 150-times summation of the samples on the simulated line hybrid 9 shown in Figure 2 (Figure 3b) compared with one another and the transmission curve of the chosen line hybrid (Figure 3c). It should be mentioned that the

accumulation of the total

signal provides a test signal sequence for the line hybrid which can be used even if the test signal level is very low (in the example -60 dB in comparison to the assumed useful signal level). This shows that the attenuation characteristic of the line hybrid can be recorded at any given time using a test signal which is well below the useful signal level, and hence without any interference with communication.

The implementation of the invention is not restricted to the described embodiment, but is also possible in a large number of modified forms. For example, other suitable test signal sequences can be used, in particular, and components other than the cyclic buffer mentioned may be used for signal accumulation. In particular, the level and attenuation values mentioned should be regarded only as examples.

Patent claims

1. A hands-free device (1) for a telephone station, having

- a transmission signal path (5) which has a received signal attenuation device (17),
- a received signal path (7) which has a received signal attenuation device (17),
- an attenuation control device (23) which is connected on the output side to the transmission signal attenuation device and to the received signal attenuation device, and
- a line hybrid (9) which connects the transmission signal path to the received signal path and connects the telephone station to an exchange line (3),

characterized by

- a test signal generator (27), which is connected to the transmission signal path (5), for producing a predetermined test signal sequence with a test signal sequence duration and a test signal level which is considerably lower than the useful transmission signal level, and for feeding this to the transmission signal path,
- a signal accumulator (31, 33), which is conneto the received signal path (7), for organized reception of the signal level over an accumulation time period which is a multiple of the test signal sequence duration, and
- an evaluation device (37), which is connected on the input side to the output of the signal accumulator (31, 33) and is connected on the output side to the attenuation control device (23), for determining a transmission characteristic of the line hybrid (9) by means of correlation analysis.

2. The hands-free device as claimed in claim 1, characterized in that, controlled by a measurement control unit (35), the test signal generator (27) produces the test signal sequence cyclically, and the signal accumulator (31, 33) has a sampling device (31) (which is operated cyclically in synchronism with the operation of the test signal generator and has an A/D converter) and a buffer memory (33) (which is connected on the input side to the sampling device, is likewise

controlled by the measurement control unit (35) and is loaded cyclically).

3. The hands-free device as claimed in claim 2, characterized in that the test signal generator (27) is designed to produce a maximum sequence as the test signal sequence.

4. The hands-free device as claimed in one of the preceding claims, characterized in that the test signal generator (27) is followed by a test signal sequence attenuation element (29), in particular with variable attenuation.

5. The hands-free device as claimed in one of the preceding claims, characterized in that the evaluation device (37) has means for determining the transfer function of the line hybrid (9) from the output signal from the signal accumulator (31, 33), in particular for carrying out a Fast-Hadamard Transformation, followed by a Fast-Fourier transformation.

6. The hands-free device as claimed in one of claims 1 to 4, characterized in that the evaluation device (37) has means for determining the test signal power transmitted to the line hybrid (9) as a transmission characteristic.

7. The hands-free device as claimed in one of the preceding claims, characterized in that the test signal level is at least 30 dB, and in particular 60 dB or more, below the useful

transmission signal level, and the signal accumulator (31, 33) carries out at least 50,

and preferably 150 or more signal accumulations.

8. The hands-free device as claimed in one of the preceding claims,
characterized
in that the attenuation control device (23) has a reference value memory (39) for storing at least one reference value which corresponds to the transmission characteristic, and has a comparator unit (23a) which is connected to the reference value memory and to the output of the evaluation unit (37), receives the transmission characteristic from the evaluation device (37) and, as the result of a comparison with the stored reference value, outputs a control signal to the transmission signal attenuation device (15) and/or to the received signal attenuation device (17).

9. The hands-free device as claimed in one of the preceding claims,
characterized
in that the transmission signal attenuation device (15) and the received signal attenuation device (17) are designed for frequency-dependent attenuation of the transmission signal and received signal, respectively, and the attenuation control device (23) is designed to output frequency-specific attenuation control signals.

10. A method for operation of a hands-free device for a telephone station,
characterized in that
- a predetermined test signal sequence with a test signal sequence duration and at a test signal level which is considerably lower than the useful transmission signal level is produced in a test signal generator (27) and is fed into a transmission signal path in the hands-free device (1),

- the signal level is received in an organized manner over an accumulation time period, which is a multiple of the test signal sequence, in a signal accumulator (33) which is connected to a received signal path (7), and

- a transmission characteristic of a line hybrid (9), which connects the telephone station to an exchange line (3), is determined by means of correlation analysis in an evaluation device (37) which is connected on the input side to the output of the signal accumulator, and is connected on the output side to an attenuation control device (23) for the hands-free device (21).

11. The method as claimed in claim 10, characterized in that the test signal sequence is produced cyclically in the test signal generator (27), and cyclic sampling is carried out, in synchronism with the operation of the test signal generator, in the signal accumulator (31, 33).

12. The hands-free device as claimed in claim 10 or 11, characterized in that a Fast-Hadamard Transformation followed by a Fourier Transformation are carried out in the evaluation device (27).

13. The method as claimed in one of claims 10 to 12, characterized in that the test signal power is evaluated as a transmission characteristic.

FIG 1

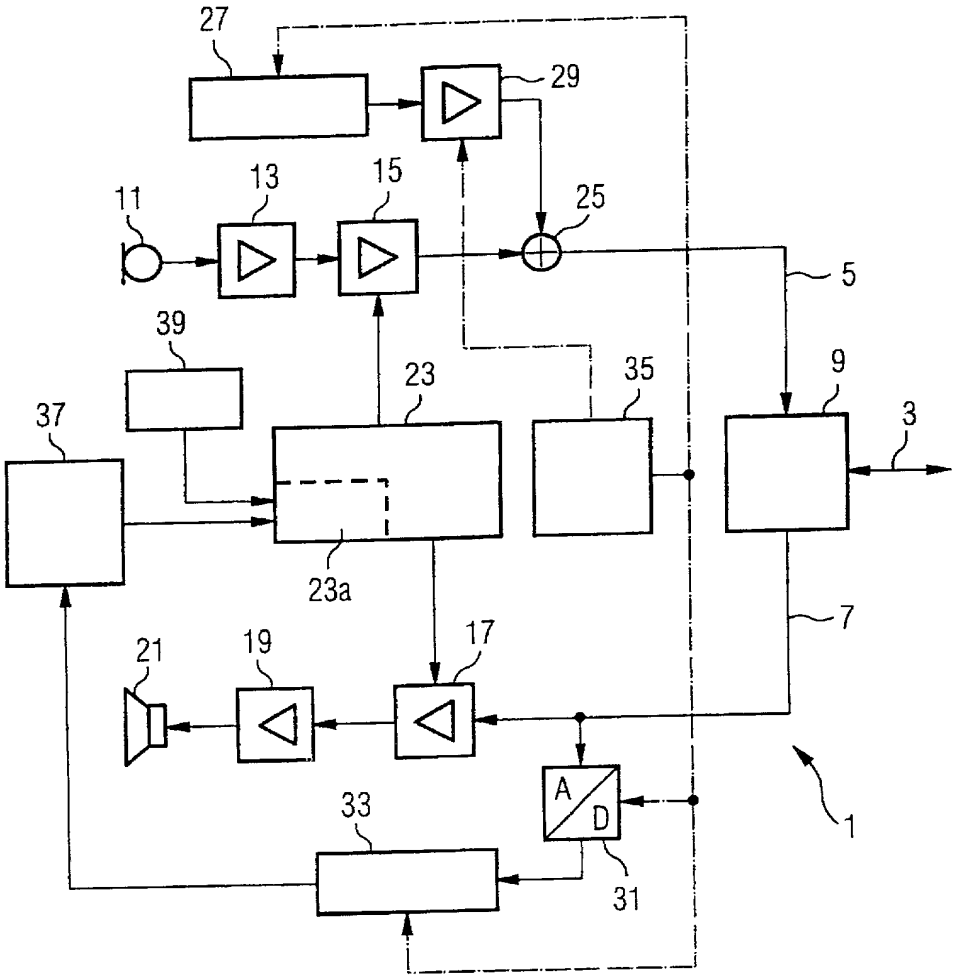


FIG 2

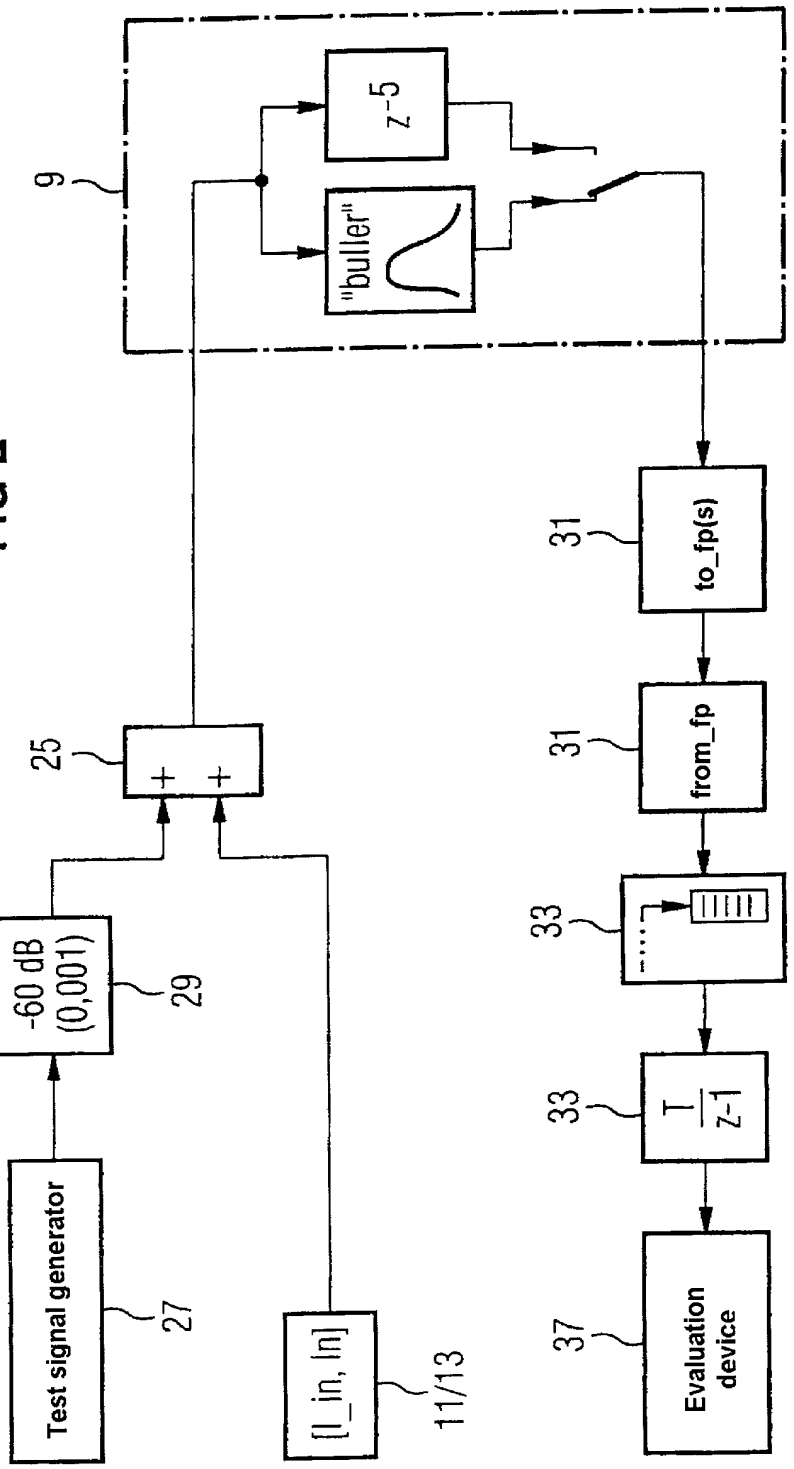

9
z-5
"buller"
25
+
+
-60 dB
(0,001)
29
Test signal generator
27
[I_in, In]
11/13
31
to_fp(s)
31
from_fp
33
33
T
z-1
37
Evaluation
device

FIG 3A

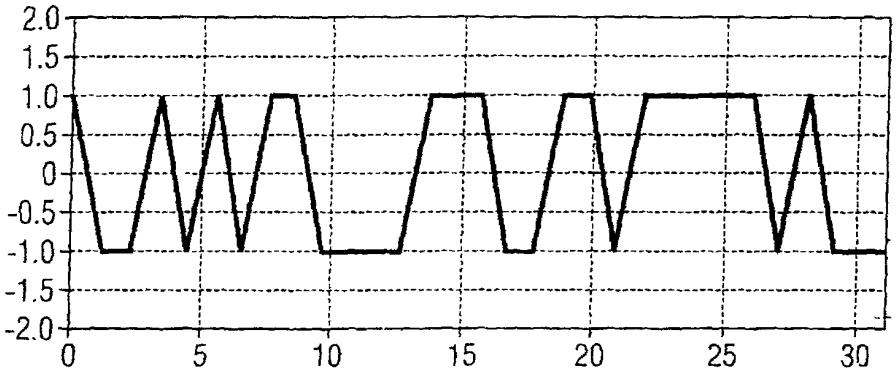


FIG 3B

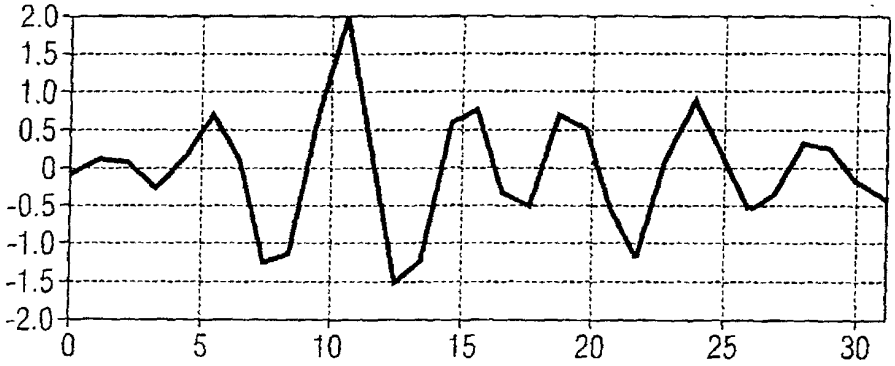
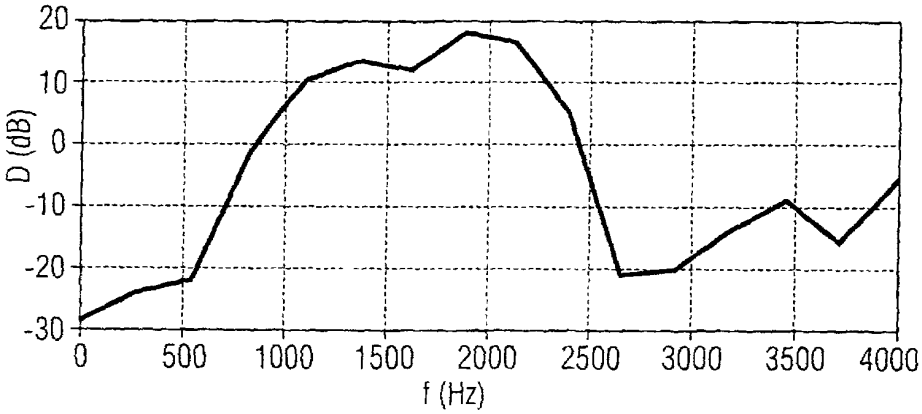


FIG 3C



Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Freisprecheinrichtung und Verfahren zum Betrieb einer solchen

Hands-free device and method of operating the same

deren Beschreibung

the specification of which

(zutreffendes ankreuzen)
☐ hier beigefügt ist.
☒ am 28.04.2000 als
PCT internationale Anmeldung
PCT Anmeldungsnummer PCT/DE00/01348
eingereicht wurde und am _____
abgeändert wurde (falls tatsächlich abgeändert).

(check one)
☐ is attached hereto.
☒ was filed on 28.04.2000 as
PCT international application
PCT Application No. PCT/DE00/01348
and was amended on _____
(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign appplications
Priorität beansprucht

			Priority Claimed	
19919370.3	DE	28.04.1999	☒	☐
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein
			☐	☐
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein
			☐	☐
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35. United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application.

PCT/DE00/01348	28.04.2000	anhängig	pending
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D, M, Y) (Anmeldedatum T, M, J)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D,M,Y) (Anmeldedatum T, M; J)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklarung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Customer No. 29177 PATENT & TRADEMARK OFFICE

And I hereby appoint

Telefongespräche bitte richten an: *(Name und Telefonnummer)*

Direct ~~Telephone~~ Calls to: *(name and telephone number)*

Ext. _____

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or
Customer No.

Voller Name des einzigen oder ursprünglichen Erfinders: KARL-HEINZ PFLAUM	Full name of sole or first inventor: KARL-HEINZ PFLAUM
Unterschrift des Erfinders Datum Karl-Heinz Pflaum 20.9.01	Inventor's signature Date
Wohnsitz BOCHOLT, DEUTSCHLAND	Residence BOCHOLT, GERMANY
Staatsangehörigkeit DE	Citizenship DE
Postanschrift GARTENWEG 27 46395 BOCHOLT	Post Office Addess GARTENWEG 27 46395 BOCHOLT
Voller Name des zweiten Miterfinders (falls zutreffend):	Full name of second joint inventor, if any:
Unterschrift des Erfinders Datum	Second Inventor's signature Date
Wohnsitz ,	Residence ,
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).